Cholesteric Liquid Crystals as Multi-purpose Sensor Materials

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Cholesteric liquid crystals (CLC) have been known since1960-ies as promising material for various sensor applications. The helical pitch of CLC can be, in appropriate conditions, extremely sensitive to different external factors; at the same time, its variation can be easily recorded using the routinely measured selective reflection/transmission spectra or, if large enough, even visually observed as changes in color. This property had been evoking much interest reflected in numerous developments of design and operation principles of CLC-based sensors or meters of temperature, electric or magnetic fields, pressure, IR radiation, acoustic waves, etc. [1,2].

In this report, we will consider several sensor applications of CLC that are related to technogenic factors affecting the environment and life conditions of human organisms. Since these factors grew more and more important with the development of technological world, these applications were re-visited several times after their initial discovery. In particular, they include detection and monitoring of ionizing radiation, biologically active UV radiation, and the presence of toxic vapors in the atmosphere.

In early works, CLC were used for detection of large doses of ionizing radiation. The action principle of such devices was based on radiation-induced chemical destruction of a substance present in the cholesteric mixture (e.g., cholesteryl iodide). The sensitivity obtained was rather low, with the smallest doses that could be detected being of the order of ~ 1 krad. Efforts in this direction resumed after the Chernobyl catastrophe, a new principle was proposed [3] to use processes of *trans-cis*isomerization of certain substances introduced to the cholesteric solvent. In such a way, sensitivities of the order of mrad were obtained; in addition, these detectors were claimed to be bioequivalent, i.e., the mechanism of their response was similar to that occurring in biological tissues. Such detectors are expected to be especially efficient at low (< 10 keV) gamma-radiation energies.

The ideas developed for CLC ionizing radiation detectors were successfully used for detection of biologically active UV-radiation. This problem became popular worldwide because of the situation of ozone layer depletion and allegedly increased dangers of harmful UV-C radiation (and,accordingly, an increasing demand for simple UV radiation indicators to be used in mountain resorts, sunlit beaches, deserts, Antarctic, etc.). It has been proposed to monitor UV radiation using CLC mixtures doped with provitamin D (the photochemical reaction provitamin D vitamin D resulted in observable changes in helical pitch) [4,5]. Our recent developments in this field are discussed, with qualitative determination of the absorbed UV radiation doses in the relevant wavelength ranges shown to be possible.

Finally, the use of CLC for detection of hazardous vapors in atmosphere that had been developed for some time in the late 1970-ies (expecting their possible use for detection of poisonous gases in chemical warfare), was recently revived (see, e.g., [6]). This was largely related to the increasing importance of anti-terrorist activities (e.g., poisonous substances getting into ventilation systems of subways, large supermarkets, etc.). The ideas originating from CLC radiation sensors were found to be useful in development of simple, cheap and sufficiently reliable CLC indicators of toxic vapors.

Further progress in all the above-described fields is to be made by passing from the stage of laboratory experiments and model devices for demonstration purposes to the development of operable instruments ensuring qualitative dosimetry or, at least, a reliable alarm indication. This requires cooperation and investments (which can be relatively small in comparison with competing devices, such as, e.g., biosensors based on carbon nanotubes or semiconductor-based UV and ionizing radiation detectors requiring sophisticated microelectronics and processing schemes).

Also presented in this report are general principles of creation of CLC sensor compositions ensuring therequired set of characteristics, which are specific for each kind of application. Our experience in this field is reviewed and discussed, with the available background claimed to be also useful for other types of CLC sensors, e.g., for visualization of thermal fields and specific kinds of electro-optic devises.

The problem is open for discussion with Korean colleagues with the aim of arranging further cooperation and eventual joint R&D projects.

References

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